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THE CURRENT STATUS OF STUDIES ON THE FUNGAL FLORA OF INDIA : AN OVERVIEW

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The taxonomy of fungi has a significant role in any application or coordination of the facts or results of pathologists, physiologists, industrialists and geneticists who have to deal with fungi. A systematic knowledge of these plant parasites is a dire necessity not only for the country where they cause plant diseases but also for quarantine, inspection and other efforts to prevent the introduction of dangerous parasites into different countries. Unless fungi in different areas have been accurately determined we cannot derive any conclusions of value as to the distribution, occurrence, or other ecological aspects. The geneticists, physiologists and industrialists have to know a still more correct identity of the fungus they deal with.

HISTORY OF TAXONOMIC STUDIES OF FUNGI IN INDIA

The early history of taxonomic studies of fungi in India has been admirably told in the introduction to Butler and Bisby's 'Fungi of India', and later by our pioneer mycologist Dr. B. B. Mundkur in his Presidential Address to the Botany Section of the Indian Science Congress in 1951. Therefore, a brief mention of the early attempts to know and classify fungi in India will be made here. These attempts started first with the studies of collections made in India by eminent mycologists in Europe, chief of whom was Rev. M. J. Berkeley, and later, two ex-army men : D. D. Cunningham, who got his training under Berkeley, Hallier and de Bary; and Major Arthur Barclay, who studied mycology under Oscar Brefeld. While some classical reports of Mucorales, Ustilaginales and Uredinales were made by Cunningham, Barclay made some notable contributions on Himalayan rusts.

According to Mundkar (1951), Lt. Col. K. R. Kirtikar was the lone Indian mycologist of the 19th century, who not only collaborated with Major B. D. Basu in the monumental work "Medicinal Plants of India", but also studied the higher fungi, chiefly the agarics, which he said are not only 'infatuating subject of observation' but are also of special interest to students of medicine. The advent of E. J. Butler in India in 1901 ushered in a new era of mycological and plant pathological activity in the country. During the nineteen years of his stay in this country, there was great mycological activity. Since then several mycologists in India have kept the banner of taxonomic mycology high in India by their notable contributions.

Comparison of the number of genera and species belonging to different classes of fungi *with the number in India* : The exact number of fungi "nobody knows" (Ainsworth, 1968). As yet a true picture of the geographical distribution of fungi in the world is not clear, as many areas still remain unexplored. Further, it is a common observation that the reports of fungi of a particular group from an area depend on the interest of the mycologists present there.

Out of over 100,000 specific names nearly 50,000 species based on morphology were considered to be 'good' species by Ainsworth (1971) and this figure can be tentatively accepted for the species of fungi known till then. The species number will continue to vary with the existence of two kinds of extremist mycologists—"lumpers" and "splitters", and with whom "consideration of convenience, tradition, and personal opinion" (Ainsworth, 1968) still reign supreme. It is also an accepted fact that many more species of fungi still remain to be recognized and described, as is substantiated by the large number of new species (1500 per year, Ainsworth, 1968) that are being reported every year. All this is true, also for India.

An estimate of the number of genera and species known in the principal classes of fungi based on the latest Edition of Ainsworth and Bisby's (1971) Dictionary of Fungi as well as the published lists of fungi in India. (Table 1). This comparative estimate is tabulated in Table 2. As will be seen that in spite of over a period of a century and half of mycological activity, there is much to be explored in this country. Certain groups of fungi have attracted the attention of our mycologists more than others among lower fungi : Myxomycetes, Oomycetes, Zygomycetes—chiefly the order Mucorales; among ascomycetes the classes Plectomycetes, Pyrenomycetes, Discomycetes and Loculoascomycetes; among basidiomycetes the Teliomycetes—Rusts and Smuts, Hymenomycetes—chiefly Aphylophorales or Polyporales; and among Fungi Imperfecti the Hyphomycetes.

With the large of phanerogams (15000 approximately) known in India, there is an equally great variety of roots available for the fungi to parasitize, and this must be having an impact on the fungus flora in our soils and leaf litter as well. Surveys made in mycologically investigated areas indicate that generally the number of parasitic fungi total approximately equal to or as high as five times the number of hosts (Bisby and Ainsworth, 1943) and the number is much more when we take into consideration the animal hosts as well (Ainsworth, 1968). The number of fungi of India known is bound to increase tremendously if more intensive explorations of all possible ecological niches are explored by competent, interested mycologists. In whatever group or area this has been done, it has resulted in not only a considerable increase in the number of species known in a group but has also added greatly to our understanding of that group of organisms. This feeling was also expressed by Thind (1974) while reviewing the work on Discomycetes in India. He said that in spite of the 400 species (275 from his laboratory alone) many more have to be discovered in view of the fact that about 3000 were known from all over the world. When this is true for macrofungi it is doubly so for microfungi for which we have to adopt often specific techniques to isolate them from nature and then to study their characteristics and life history to establish their identity. To further substantiate this point, let me give in some detail the progress made in the mucoraceous flora of India, with which I had been directly concerned. Work in India in the order Mucorales can be easily divided into two phases of activity : one beginning from the year

Table 1 : The different lists of fungi of India published from time to time. The figures below each reference .denote the number of species listed.

Butler & Bisby (1931)
upto 1931 →
2351 (excl. Myxo)

Mundkur (1938)
1931-1938 →
524 (incl. 90 Myxo)

K. Ramakrishnan
&
C. V. Subramanian (1952)
1938-1951
812

Subramanian &
Ramakrishnan (1956)
1952-1956 →

Subramanian &
Tyagi (1964)
1956-1960
778

Vasudeva [1954 (1960)] →
upto 1952
3895

Vasudeva (1962) →
1953-1957
1006

Tondon & Chandra (1964)
1957-1962
1465

→ Tilak & Rao (1968) →
1962-1967
2329

Sarbhoy *et al.* (1975)
1967-1971
1000

Mukherji & Juneja (1975)
1962-1972
3435

Table 2 : List of genera and species known and the number known in India till 1971.

CLASS	PERIOD	WORLD FIGURE		IN INDIA	
		Genera	Species	Genera	Species
1. Myxomycetes	1952			27	88
	1971	70	400	35	201
2. Plasmodiophoromycetes	1952			3	3
	1971	14	35	3	3
3. Chytridiomycetes	1952			10	45
	1971	110	575	13	152
4. Hyphochytridiomycetes	1952				
	1971	7	15	—	—
5. Oomycetes	1952			25	106
	1971	70	550	28	170
6. Zygomycetes	1952			14	43
	1971	85	510	30	179
7. Trichomycetes	1952				
	1971	30	100	—	—
8. Hemiascomycetes	1952			6	14
	1971	60	325	8	22
9. Plectomycetes	1952			27	97
	1971	160	2250	47	221
10. Pyrenomycetes	1952			97	285
	1971	640	6000	167	564
11. Discomycetes	1952			48	94
	1971	425	3000	102	275
12. Laboulbeniomycetes	1952			6	17
	1971	130	1500	6	17
13. Loculoascomycetes	1952			58	180
	1971	550	2000	103	408
14. Teliomycetes	1952			83	831
	1971	175	6000	95	1059
15. Hymenomycetes	1952			120	834
	1971	675	5000	142	1069
16. Gasteromycetes	1952			28	81
	1971	150	700	37	129
17. Coelomycetes	1952			86	462
	1971	870	7000	119	1047
18. Hyphomycetes	1952			?	?
	1971	930	7500	163	482

1815, when Cunningham described the first species of the order Mucorales in India, *viz.*, *Choanephora* sp. on *Zinnia* and ending in the year 1956 and another post-1956 period. During the first phase covering a century and a half, nearly 39 species belonging to 11 known genera and one new genus (*Saksenaea*) were reported. The report of the very interesting new genus *Saksenaea* by S. B. Saksena was the most notable contribution of this period. Galloway (1936), the Imperial Mycologist of the then Imperial Institute of Agricultural Research, Pusa, in his paper on the soil fungi of India could find only 5 species belonging to 4 genera of this order, with only 3, identified upto the species level. He remarked that probably in the tropical climate of India there is paucity of mucoraceous flora in our country especially in our soils. But subsequent work has proved that this was not true. In fact what was needed was a concerted attempt to search for them. Intensive investigations initiated with the help of a project lasting for 5 years (1961 to 1966) and subsequent work, in our laboratory and some reports from other laboratories scattered throughout the country, have altered our previous knowledge of the mucoraceous flora of our country. From nearly 40 species belonging to 12 genera of the order known till 1956, over 135 species belonging to 26 genera of this order are now known. And this is not enough, much more is in store. I can say with confidence, looking at the number of new finds under study, that we are a very rich nation as regards our mycological flora. The genus *Mortierella* used to be considered a genus of temperate climates, as it was reported extensively from soils of foreign lands with such a climate. Now from our laboratory alone, 17 species of this genus have been reported, out of which 7 are new, one of which (*M. wolfii* Mehrotra & Baijal) has been reported from soil collected from the desert area of Jobner (near Jaipur) and is one of the few species of this order reported to be thermophilic, although now we have many more in store which we hope to publish soon. A few of the monotypic genera (such as *Thamnocephalis, Pirella* and *Blakeslea*) of the order have now more species. A genus (*Thamnocephalis*), unheard since 1906 when it was first reported by Blakeslee, was reported from India in 1964 and it turned out to be a new species (*T. ovalispora* Mehrotra & Mehrotra) of this genus. Also, a genus (*Blakeslea*) which was increasingly being believed to be a synonym of another genus *Choanephora*, was revalidated on the basis of the discovery of a new species of that monotypic genus. Out of only two azygosporic species of *Mucor* known one has been found to be in India. It has also been contended that except in *Syncephalastrum*, in other so called merosporangiferous Mucorales, a true merosporangium does not exist, but only merosporangial fundaments which fragment into conidia (Mehrotra 1967; 1973).

There are other examples which prove that devotion to taxonomic studies of one or more groups has resulted in a revelation of extensive fungus flora which otherwise would have been hidden. Notable ones are : Floristic studies of polypores, by S. R. Bose, S. N. Banerjee, B. K. Bakshi and presently by K. S. Thind and his associates; of smuts and rusts by B. B. Mundkur, M. J. Thirumalachar, and M. S. Pavgi; of ascomycetes by M. N. Kamat and his associates; of Myxomycetes and Discomycetes by K. S. Thind and his associates; of Hyphomycetes by C. V. Subramanian. The wealth of our fungus flora of aquatic lower fungi from fresh-water and marine environments and from soils in southern India is shown by J. S. Karling's two short visits to India. His monograph on Indian chytrids and other zoosporic fungi reports 145 species of chytrids belonging to 20 genera and 33 species of other zoosporic fungi. (Karling, 1966).

As yet, the classes of fungi Hyphochytriales, Trichomycetes, and orders Monoblepharidales, Harpochytriales, Coronophorales and Coryneliales have not received the attention of Indian mycologists, and little progress has been made in our knowledge of Plasmodiophorales (3 species only), yeasts, Tuberales (only two reports made as early as 1892 ; 1949) and Laboulbeniales. Someone should get interested in these groups of fungi.

One significant role of fungi lies in their wonderful biosynthetic capacity which has been utilized by man for industrial production of certain useful chemicals. We, in India, have depended for whatever fermentation industries we have, mostly on the strains from foreign countries. However, there is no doubt that useful strains of fungi exist in Nature and such indigenous strains could be used to our advantage. My own experience with collecting strains of *Aspergillus niger* group from nature on a selective medium, which resulted in the isolation of over a dozen promising strains for industrial production of citric acid, is quite convincing.

CONCLUSIONS

1. A more intensive survey of the fungi of India should be undertaken in all possible ecological niches : water (fresh and marine), soil (soil-inhabiting and root-inhabiting), terrestrial (obligate saprobes, secondary invaders and parasites) and air. This survey may be done not state-wise, but on the basis of botanical regions, elaborately defined by Calder (1937) and later modified by Chatterjee (1962), *viz.*, Western Himalayas, Central Himalayas, Eastern Indus Plain, Gangetic Plain, Deccan and Malabar. The type of vegetation of the area (alpine, plains, desert, deciduous, hill evergreen, and estuarine) should also be taken into consideration. This can only be achieved by a coordinated programme sponsored by all the central agencies responsible for development of Science in India—the Botanical Survey of India, ICAR, CSIR and UGC—inviting all mycologists, experienced or beginners.

2. An upto-date list of fungi of India is very much needed. This list should be based on the current accepted classification and the fungi should be listed alphabetically within the different larger taxonomic groups. This list should be prepared by a group of mycologists representing the groups they have specialised and with one or two editors to bring uniformity in the work. The indiscriminate preparation of lists of fungi has resulted in repetitions on a grand scale and overlapping of years covered by different lists.

3. We still have to establish a prestigeous Culture Collection of fungi and to develop our national herbarium. Our mycologists have to rely more on cultures from foreign countries for comparative studies and have to depend on the advice of foreign experts of the groups of fungi because even the type cultures of the fungi described from India are generally not available here. Not only a campaign for collection of type cultures be made in our country but types should be solicited from other countries. Unless that is done, we can not present monographic treatments of any group of organisms. All we can do and have been doing, is to present a consolidated account of what has been done in India. A culture collection is necessary for teaching also and, therefore, I had pleaded for its establishment at the Science Congress Symposium on teaching of mycology in India in 1970. Further, the need for establishment of a culture collection to serve the growing fermentation industries in India is of great national importance. I had pleaded for the establishment of an international culture collection for industrial microorganisms before an international gathering of Microbiologists

in Tokyo in 1968 (Mehrotra, 1970) and although the idea was accepted it could not come up for some reason. However, many of us had been working on problems of industrial importance and the good strains we develop or collect during the course of our work are dumped up in the respective laboratories and are soon lost because of lack of further interest and facilities. Such a waste of human effort can be prevented by establishing a culture collection of industrial microorganisms for the country.

Just as it is essential that our cultures and herbaria be preserved so also it is necessary that the laboratories which have shown good work should be conserved by governmental support. Taxonomic laboratories are not established overnight; they gradually come up by one man's effort who leads the team of workers and with his retirement the laboratory should not be allowed to perish, as it often happens.

4. *The need for cooperative effort* : Taxonomic studies in general and more so of fungi often require interchanges of courtesies and assistance between taxonomists interested in the same or related groups of organisms. We can cooperate by supplying cultures or materials and if necessary join hands on similar problems, with of course some agreement as to division of work and mode of final publication. However, where no such cooperation is needed individuals should be free to follow the dictates of their conscience to undertake research of their choice. They should always be encouraged, funds and facilities be provided to them and administrative restrictions wherever existent be removed.

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